

EM 538/ISE 538 Practical Machine Learning for Engineering Analytics

Summer 2025 Course Syllabus

COURSE INFORMATION

- **Course Website:** <https://moodle-courses2527.wolfware.ncsu.edu/course/view.php?id=1034>
- **Course Credit Hours:** 3
- **In-Person Meeting Time:** Online Delivery
- **Prerequisites/Corequisites:** Graduate Standings in Engineering
- **Office Hours:** Weekly Wednesday 3:00 – 5:00pm or by request.
<https://ncsu.zoom.us/j/9197954710?pwd=cnk0V1BMUmFIdDhwMGJueGdlcFhyQT09&omn=92545327455&jst=3>

INSTRUCTOR INFORMATION

Name	Office	Contact	Office hours
Professor: Fred Livingston, Ph.D.	FWH 4109	fjliving@ncsu.edu 919-515-1549 (Office)	Wednesday 3pm Weekly (zoom) and by request. Night and weekends appointments are also available by request. https://calendly.com/fjliving

COURSE DESCRIPTION

Machine learning has become integral to engineering analytics, significantly improving predictive capabilities and providing valuable insights from complex datasets. In engineering, machine learning models can analyze vast amounts of data from multiple sources to identify patterns and make accurate predictions. These predictions can optimize system performance, predict equipment failures, and improve maintenance schedules. Machine learning techniques transform how engineers approach problem-solving, enabling them to make more informed decisions and implement more effective solutions. One of the critical aspects of this course is the focus on practical examples and hands-on experience with machine learning tools and techniques. Through lectures, case studies, interactive assignments, and projects, students will gain a comprehensive understanding of machine learning applications in engineering analytics. The

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The course will cover fundamental machine learning concepts, such as supervised and unsupervised learning, classification, regression, anomaly detection, clustering, neural networks, and time series predictions. Students will also learn about different types of algorithms and their applications to engineering problems. The course will also cover data preprocessing, feature selection, model training, and evaluation. Students will work on projects that simulate real-world scenarios, allowing them to apply their knowledge and skills in a practical setting. This will enable them to deeply understand how machine learning can be used to solve complex engineering problems and make informed decisions.

ASSESSMENT

Grading Policy

Module Assessments (Quizzes) (4) – **35 pts**

- Introduction and Computational Foundation Model Evaluation
- Classical Machine Learning Models and Model Evaluation
- Tree-based Models
- Introduction to Deep Learning

Class Collaborative Discussions (10) – **10 pts**

Programming Assignments (5) – **40 pts**

- KNN Model
- Model Evaluation
- Tree-Based Models
- Neural Networks
- Time-Series Prediction

Final Exam Project (1) – **15 pts**

- Documentation (README, User Guide, etc.)
- Project Report
- Project Presentation

*** Project progress will be tracked via Google Collab

Grading Scale

Grade range	Grade letter equivalent
98-100	A+
94-97	A
90-93	A-
87-89	B+
83-86	B
80-82	B-
77-79	C+
73-76	C
70-72	C-
67-68	D+
63-66	D
61-62	D-
60 and below	F

COURSE POLICIES

Late Assignments – Assignments must be submitted by the due date. Late assignments are reduced 2% per day for up to 10 days. After 10 days, assignments are not accepted. No assignment may be submitted after the last day of class.

Exam – The exam in this course are closed book and notes, unless stated open book. Neither the Internet (i.e., Google, nor other people, may be consulted during an exam. Exams must be completed during the specific time in one single sitting subject to a time limit. Exam may cover anything from the readings or lectures.

Assignment Submission - Assignments must always be submitted via the Moodle assignment link and not by email.

Grades - Course and assignment grades, whether machine graded or graded by the instructor, are final and not subject to negotiation. Students may not email at the end of the term and ask for one more point to get a higher grade, as this creates an unfairness to other students. Grades are based on the university grading scale.

LEARNING OUTCOMES

- Use the essential components of building and applying prediction functions
- Describe machine learning methods such as regression and classification trees
- Understand concepts such as training and test sets, overfitting, and error rates
- Explain the complete process of building prediction functions

- Organize, manage, and evaluate machine learning projects.

COURSE MATERIALS

Recommended Textbook, Videos, and Supplementary Materials

(Optional Textbook)

Raschka, Sebastian., Liu, Yuxi (Hayden)., Mirjalili, Vahid., Dzhulgakov, Dmytro. Machine Learning with PyTorch and Scikit-Learn: Develop Machine Learning and Deep Learning Models with Python. United Kingdom: Packt Publishing, 2022.

(Optional Textbook)

Raschka, Sebastian. Build a Large Language Model (From Scratch). September 2024 ISBN 9781633437166

Course Discord Group:

<https://discord.gg/yXzbcqASnH>

Josh Starmer's State Quest:

Statistics, Machine Learning, and Data Science YouTube Channel

<https://www.youtube.com/@statquest>

A Visual Introduction to Machine Learning:

<http://www.r2d3.us/visual-intro-to-machine-learning-part-1/>

DISTANCE EDUCATION (EOL)

This course has been adapted to meet the growing popularity of a remote diverse team collaboration environment. This course will encourage communication with the in-seat students using Discord and peer software collaboration using Google Collab. You may group with in-seat students to complete the capstone project. All assignments will be submitted electronically and due at the same time as the in-seat students.

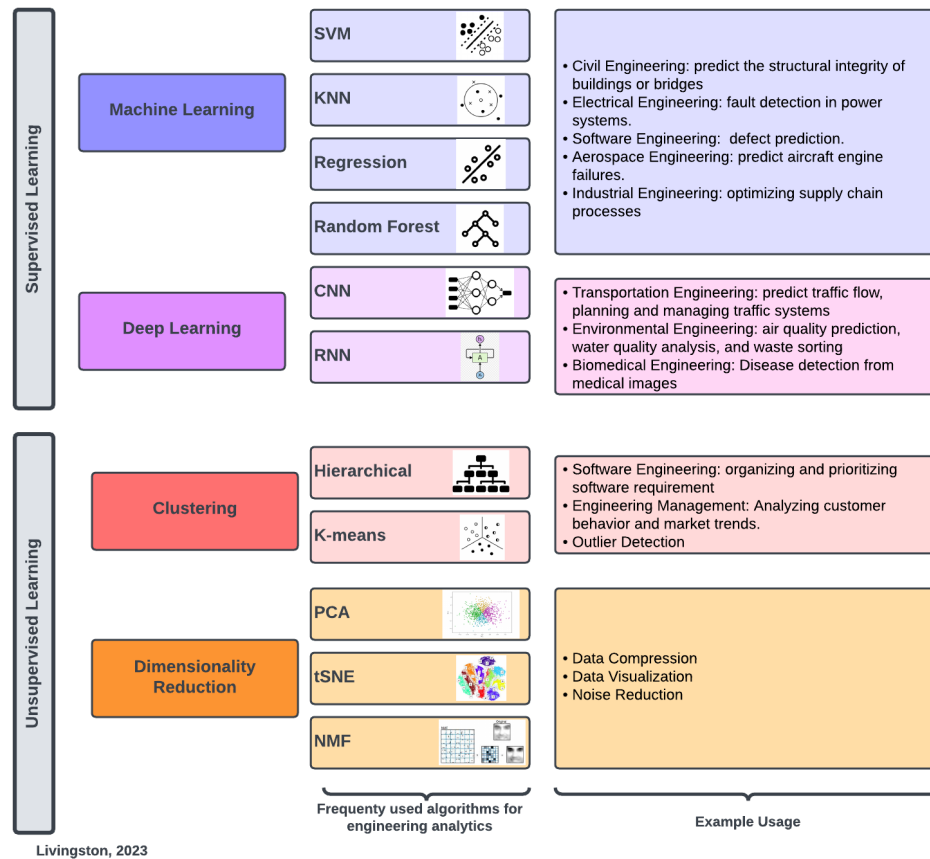


Figure 1. Practical Machine Learning for Engineering Analytics

TECHNOLOGY REQUIREMENTS

This course includes individual machine learning assignments and group projects with project management tasks. Students will need a personal computer with administrative rights to collaborate outside of class.

COURSE OUTLINE

The course will include lectures, demonstrations, in-class assignments, programming assignments, and projects. Please make sure to bring your personal computers to class so you can follow along with the instructor. Additionally, there will be guest seminars on emerging topics of AI throughout the semester. Towards the end of the semester, class time may be used for project presentations, coding, and extended office hours.

Module 1: Introduction and Computational Foundation [W1, W2]

- Course overview and Introduction to Machine Learning
- Introduction to Python's scientific computing stack
- Machine Learning Development Tools and Data Visualization (VScode, Google Coolab streamlit, plotly, etc)
- Introduction to Supervised Learning and k-Nearest Neighbors Classifiers
- Data preprocessing and machine learning with scikit-learn

Module 2: Classical Machine Learning Models and Model Evaluation [W3, W4]

- Cross-Validation and Model Selection
- Evaluation and Performance Metrics
- Classical Machine Learning Models: Clustering
- Classical Machine Learning Models: Regression
- Classical Machine Learning Models: Principal Component Analysis

Module 3: Tree-based Models and Feature Selection [W5, W6]

- Feature Selection
- Feature Extraction
- Algorithm Selection
- Tree-based models: Decision Trees
- Tree-based models: Ensemble

Module 4: Introduction to Deep Learning [W7, W8, W9]

- Perceptron's and Tensors
- PyTorch
- Single and Multilayer Neural Networks
- Tokenizer
- Recurrent Neural Networks (Time series predictions)

Module 5: Course Project [W10]

COURSE SCHEDULE

SCHEDULE

<https://docs.google.com/spreadsheets/d/1AIDigz60DpTuzMrldHlxswOv8rMnP7Qz7xjAhb41C6I/edit#gid=0>

A	B	C	D	E	F
Week	Date		Topic(s)	Book Chapter(s)	Assessment(s)
1	5/12/2025	Module 1: Introduction and Computational Foundation	L1. Course Introduction and Python "Hello World"	Ch 1. pg 1 - 18	
			L2. Python Data Types		
			5/14 First Day of Classes		
2	5/19/2025		L3. Data Wrangling and Visualization	Ch 4. pg 105-122	Week 1 Discussion (due)
			L4. Introduction to Machine Learning Models	Ch 3. pg 98-103	
3	5/26/2025	Module 2: Classical Machine Learning Models and Model Evaluation	L5. KNN Supervised Learning Models		Hw1 (assigned): KNN model and data wrangling
			L6. KNN Supervised Learning (Part 2)		Week 2 Discussion (due)
			5/26 Memorial Day		Module 1 Quiz (due)
			L7. Model Performance and Clustering	Ch 6 pg. 171 - 204	Week 3 Discussion (due)
4	6/4/2025		L8. Kmean Clustering	Ch 9	
			L9. SGD Regressor		Hw1 (due)
			L10. PCA		Hw2 (assigned): Other Models
5	6/9/2025				Week 4 Discussion (due)
			L11. Common Feature Selection	Ch 10	Week 5 Discussion (due)
			L12. Decision Trees	Ch 4 pg. 122 - 137; Ch 3 pg 86 - 97	Module 2 Quiz (due)
6	6/16/2025	Module 3: Tree-based Models and Feature Selection	6/19 Juneteenth Observed		
			L13. Ensemble Methods	Ch 7 pg. 205-245	Hw2 (due)
					Hw3 (assigned): Decision Trees and Ensemble Methods
7	6/23/2025		5/26 Memorial Day		Week 6 Discussion (due)
8	7/2/2025		7/4 Independence Day		
9	7/7/2025	Module 4: Introduction to Deep Learning	L14. Perception	Ch 7 pg. 229-245	Week 7 Discussion (due)
			L15. Single Layer Neural Networks		Project Proposal (due)
					Module 3 Quiz (due)
10	7/14/2025		L16. Multi Layer Perception		Hw3 (due)
			L17. Google Collab		Hw4 (assigned): Neural Networks
					Week 8 Discussion (due)
			L18. Recurrent Neural Networks	Ch 2. pg 20 - 25; Ch 12 pg 369 - 380	Week 9 Discussion (due)
			L19. LSTM		
11	7/21/2025	Module 5: Final Project	7/26 Last day of classes		
					Hw4 (due)
					Week 10 Discussion (due)
					Module 4 Quiz (due)
12	7/28/2025		7/28 Final Examination		Term Project (due)

STUDENT RESOURCES

Academic and Student Affairs maintains a website with links for student support on campus, including academic support, community support, health and wellness, financial hardship or insecurity, and more. [Find Help on Campus.](#)

Disability resources

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the [Disability Resource Office \(DRO\)](#). For more information on NC State's policy on working with students with disabilities, please see the [Policies, Rules and Regulations page maintained by the DRO](#) and [REG 02.20.01 Academic Accommodations for Students with Disabilities](#).

Safe at NC State

At NC State, we take the health and safety of students, faculty and staff seriously. The [Office for Institutional Equity and Diversity](#) supports the university community by providing services and resources to support and guide individuals in obtaining the help they need. See the [Safe at NC State webpage](#) for resources.

Supporting Fellow Students in Distress

[Example: As members of the NC State Wolfpack community, we each share a personal responsibility to express concern for one another and to ensure that this classroom and the campus as a whole remain a healthy and safe environment for learning. Occasionally, you may come across a fellow classmate whose personal behavior concerns or worries you, either for the classmate's well-being or yours. If you feel this way, I would encourage you to report this behavior to the [NC State CARES website](#). Although you can report anonymously, it is preferred that you share your contact information so they can follow up with you personally.]

Wellness Resources

- **[WolfPack Wellness](#)** website: the university's overarching wellness site, providing information about most of the university's programs and services. Includes both a [high level](#) and a [comprehensive list](#) of programs and services.
- **[NC State Counseling Center](#)**, list of [counseling services](#), including [AcademicLiveCare](#) (counseling telehealth).
- **[College of Textiles Embedded Counselor](#)**, Michael Tuma (shared with Graduate School).
- **[TaskHuman](#)**: FREE UNLIMITED one-on-one well-being coaching they can receive through TaskHuman in the following areas: physical fitness, professional development, mental & emotional support, healthy watching & food choices, spiritual practice & guidance, personal growth & development, etc.
- **[Pack Essentials](#)**: NC State and campus partners have developed many programs to support students in need of food, housing, financial and educational security. Includes [food and housing resources](#) (including Feed the Pack Pantry), [financial resources](#) (includes Student Emergency Fund and PACK ASSIST), [student legal services](#), and many others.
- **[Campus Community Centers](#)**: [African American Cultural Center](#), [Multicultural Student Affairs](#), [LGBTQ Pride Center](#), and [Women's Center](#).
- **[Student Ombuds](#)**: An independent, neutral, confidential, and informal office at NC State, Student Ombuds Services is here to be a personal guide for conflict management, prevention and resolution while advocating for fair processes and empowering students to successfully navigate NC State.

UNIVERSITY POLICIES

Academic Integrity and Honesty

Students are required to comply with the university policy on academic integrity found in the [Code of Student Conduct](#). Therefore, students are required to uphold the university pledge of honor and exercise honesty in completing any assignment. Please refer to the [Academic Integrity](#) web page for a detailed explanation of the University's policies on academic integrity and some of the common understandings related to those policies. Violations of academic integrity will be handled in accordance with the Student Discipline Procedures ([NCSU REG 11.35.02](#)).

For use in courses with online exchanges among students and the instructor, but NOT persons outside the course:

Students may be required to disclose personally identifiable information to other students in the course, via electronic tools like email or web-postings, where relevant to the course. Examples include online discussions of class topics and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

Students are responsible for reviewing the NC State University PRR's which pertains to their course rights and responsibilities, including those referenced both below and above in this syllabus:

- > [Equal Opportunity and Non-Discrimination Policy Statement](#) and [Additional References](#)
- > [Code of Student Conduct](#)
- > [Grades and Grade Point Average](#)
- > [Credit-Only Courses](#)
- > [Audits](#)

Students with Disabilities

Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the [Disability Resource Office](#) at Holmes Hall, Suite 304, Campus Box 7509, 919-515-7653 . For more information on NC State's policy on working with students with disabilities, please see the [Academic Accommodations for Students with Disabilities Regulation \(REG02.20.01\)](#)

Basic Needs Security

Any student who faces challenges securing their food or housing or has other severe adverse experiences and believes this may affect their performance in the course is encouraged to notify the professor if you are comfortable in doing so. Alternatively, you can contact the Division of Academic and Student Affairs to learn more about the Pack Essentials program <https://dasa.ncsu.edu/pack-essentials/>

DEPARTMENT POLICIES

The Department strives to provide an environment conducive to learning and believes strongly in the Code of Student Conduct (POL 11.35.01). The portion below, extracted from POL 11.35.01, is specific to academic misconduct:

8 ACADEMIC MISCONDUCT

All members of the University community, students, faculty and other employees, have the responsibility to report academic misconduct to the appropriate authority. Faculty members must undertake a threshold responsibility for such traditional safeguards as examination

security and proctoring and should clearly communicate their academic expectations in the course syllabus. The use of the Pack Pledge, "I have neither given nor received unauthorized aid on this test or assignment," on all syllabi, assignments, examinations, or other academic evaluations is encouraged. Similarly, faculty members should familiarize themselves with the procedures for addressing academic misconduct. The procedures for reporting academic misconduct can be found in **[NCSU REG11.35.02 - Student Discipline Procedures](#)**.

Definitions regarding academic misconduct are set forth in writing in order to give students general notice of prohibited conduct. They should be read broadly and are not designed to define academic misconduct in exhaustive terms. If a student is in doubt regarding any matter relating to the standards of academic integrity in a given course or on a given assignment, that student must consult with the faculty member responsible for the course before presenting the work.

8.1 Aiding and Abetting

Aiding and abetting others to cheat or plagiarize is as detrimental to the scholarly community as engaging in the acts themselves. Aiding and abetting others to cheat or plagiarize includes, but is not limited to, the following:

- (a) Giving unauthorized assistance to another or others during a test or evaluation;
- (b) Posing as another student in order to meet a course or graduation requirement;
- (c) Providing specific information about a recently given test, examination, or assignment to a student who thereby gains an unfair advantage in an academic evaluation;
- (d) Providing aid to another person, knowing such aid is expressly prohibited by the faculty member, in the research, preparation, creation, writing, performing, or publication of work to be submitted for academic evaluation;
- (e) Permitting one's academic work to be represented as the work of another; or
- (f) Sharing or distributing academic materials, including class notes, in violation of the **[UNC Policy Manual 500.2 – Patent and Copyright Policies](#)** or **[NCSU REG01.25.02 – Copyright Infringement – Policy Statement](#)**.

8.2 Cheating

Cheating is the giving, taking, or presenting of information or material by a student that unethically or fraudulently aids oneself or another person on any work which is to be considered in the determination of a grade or the completion of academic requirements or the enhancement of that student's record or academic career. Cheating includes, but is not limited, to the following actions:

- (a) Copying from someone else's assignment, examination, or other academic exercise;
- (b) Possessing, buying, selling, removing, receiving, or using, at any time or in any manner not prescribed by the faculty member, any information related to an instrument of academic evaluation;
- (c) Using materials, equipment, or assistance in connection with an assignment, examination, or other academic exercise which have not been authorized by the faculty member, including but not limited to, notes, calculator, or other technology;

- (d) Obtaining or attempting to obtain, in a dishonest manner, any material relating to a student's academic work;
- (e) Working with another or others in completing an assignment, examination, or other academic exercise when the faculty member has required independent and unaided action;
- (f) Attempting to influence or change an academic evaluation, grade, or record by unfair means;
- (g) Permitting another individual to substitute for one's self in an academic evaluation;
- (h) Marking or submitting an examination or evaluation material in a manner designed to deceive the grading system;
- (i) Failing to comply with a specific condition of academic integrity which has been clearly announced in a particular course;
- (j) Submitting, without prior permission of the faculty member, any work by a student which has at any time been submitted in identical or similar form by that student in fulfillment of any other academic requirement at any institution;
- (k) Submitting of material in whole or part for academic evaluation that has been prepared by another individual(s);
- (l) Submitting data which have been altered or contrived in such a way as to be deliberately misleading; or
- (m) Providing false information to the University in any manner to achieve an unfair advantage, enhance one's record, or complete a requirement.

8.3 Destruction or Removal of Academic Materials

The destruction or removal of academic materials denies access to, and prevents the ability to develop the full potential of, scholarly resources. Prohibited acts under this section include, but are not limited to, the following:

- (a) Removing or attempting to remove, destroy, steal, or make inaccessible library or other academic material without authorization; or
- (b) Willfully damaging the academic work or efforts of another.

8.4 Plagiarism is the use or close imitation of the language and thoughts of another and the representation of the other's work as their own. The act of submitting work for evaluation or to meet a requirement is regarded as assurance that the work is the result of the student's own thought and study, produced without assistance, and stated in that student's own words, except as quotation marks, references, or footnotes acknowledging the use of other sources. Any ideas or materials taken from another source for either written or oral use must be fully and correctly acknowledged. Submission of work used previously must first be approved by the faculty member. Plagiarism includes, but is not limited, to the following actions:

- (a) Representing the work of others as his or her own; or
- (b) Submitting written materials without proper attribution or acknowledgment of the source.